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An investigation of the application of a specialized computer program to the study of sensory evoked responses was completed. The purpose of the study was to determine the applicability of the program in assessing aircrew performance. The study indicated that the averaged evoked response, the fast fourier transform and a specialized program, ALPHAF, could not detect very early conditions of hypoxia and are therefore not applicable to assessment of aircrew performance.

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APPLICATION OF A SPECIALIZED STATISTICAL COMPUTER PROGRAM, ALPHAF, TO A SENSORY EVOKED RESPONSE DATA ANALYSIS SYSTEM

FINAL REPORT

[redacted] Research Grant Number [redacted]
AFOSR-78-3689

James M. Verlander
Texas A&M University
College Station, Texas 77843
December 1980

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APPLICATION OF A SPECIALIZED STATISTICAL COMPUTER PROGRAM, ALPHAF, TO A SENSORY EVOKED RESPONSE DATA ANALYSIS SYSTEM

I. INTRODUCTION

Development of high performance aircraft has increased the importance of rapid in-flight aircrew performance evaluation. The purpose of this investigation was to determine the applicability of a specialized computer program in the assessment of crew performance. Crew performance in this study was defined as neurological processing of sensory data, that is, the sensory processing ability of the human brain during normoxic and hypoxic environments. There were four goals of this investigation: (1) to continue study of the applicability of sophisticated computer data reduction techniques in the investigation of sensory processing in humans, (2) to determine impact of new sensory data on existing USAF/SAM computer models of human performance, (3) to provide a feasibility judgment for an onboard device that would monitor aircrew sensory processing capability, (4) to provide new information on sensory processing for follow-on research into radiation insult to the brain. The computer analysis techniques used were the Fast Fourier Transform (FFT), the specialized statistical program ALPHAF, and the Evoked Response (ER) averaging techniques.

II. METHODS

Ten human volunteers were used as test subjects. The evoked responses observed were: the Visual Evoked Response (VER), the Auditory

Evoked Response (AER), and the Somatosensory Evoked Response (SER).

The visual stimuli were presented to subjects by an electronic system identical to the one utilized by USAF/SAM. The stimulus, presented on a television screen, was a vertically oriented grid pattern (square wave) with a target size of 3.5° visual angle, a spatial frequency of 3 cycles per degree of visual angle and a counter phase frequency of 10 cycles per second. The small visual angle provided foveal stimulation which resulted in a VER generated from only the posterior surface of the visual cortex.

Audiometry was obtained by use of a Grass Instrument Corporation Click Stimulus Generator. The click rate was 10 per second with intensity values ranging from 5 to 75 dB sensation level (SL), with monaural presentation.

The somatosensory stimuli were presented to the medial nerve at the wrist by a Grass Instrument Stimulus Generator. Stimulus was in a range of 0-100 volts with a square wave duration of 0.1 milliseconds and a current of 0 to 19.9 milliamperes.

Recording Set-Up, Hypoxia, Subject Safety:

The sensory evoked responses, along with the electroencephalogram (EEG) and electrocardiogram, were simultaneously recorded on FM magnetic tape and strip chart. All recordings were made with the subjects in a shielded room. All EEGs were taken from electrodes placed on the scalp. Averaged response data was made in a real time mode during the last ten seconds of each recording period.

Arterial blood oxygenation levels were established by presenting various gas mixtures to the test subject via a hand held breathing mask. Gas mixtures of varying oxygen and nitrogen concentrations were used to produce the hypoxia found at altitudes of 10,000, 20,000 and 30,000 feet. The mixtures took into account the constant values of alveolar carbon dioxide and water vapor tensions. The gas mixtures were mixed by the Hyperbaric Laboratory at Texas A&M University. No invasive methods were used to determine arterial oxygenation.

As the intent of this investigation was to find a means of detecting early decrements in sensory processing, experimentation was not planned to go beyond the point of awareness of hypoxia by the subject. No subject was exposed to hypoxia longer than ten minutes at 10,000 and 20,000 feet equivalents and fifteen seconds at 30,000 feet equivalent, i.e., a time not to approach the period of awareness by the subject.

III. DATA ANALYSIS TECHNIQUES

Tne analogue data were converted to digital form by Texas A&M University's Analogue/Digital (A/D) Conversion System. Two unfortunate incidents occurred during the data processing: (1) the original analogue tape was stretched during the A/D conversion, rendering it useless, and (2) the digital tape was inadvertently erased by the Data Processing Center following the investigator's release from TAMU employment. Some of the data was salvageable; the A/D conversion of the VER and the averaged SER and AER (the A/D conversion of the SER and AER was destroyed). The digital VER data were processed by the FFT/ALPHAF

technique.

IV. RESULTS

The ALPHAF program indicated no statistical difference between the VERs of humans breathing gas mixtures simulating conditions of normoxia, at 10,000, 20,000 and 30,000 feet altitudes. A comparison of the averaged VER, SER AND AER showed the same result. The 30,000 feet equivalent gas mixture was the most extreme condition of hypoxia and therefore its data were chosen as representative of the results of this study (Figure 1, 2 and 3). In an attempt to show significant differences between groups, manual calculation of the PSD function of the averaged evoked responses for the SER and/or AER for four individuals was accomplished. The calculated values were indistinguishable from each other and therefore no further attempts were made to reduce the data in this very time consuming fashion.

V. CONCLUSIONS

Although a large volume of data was lost from FFT analysis, the FFT/VER data along with the averaged VER and AER indicate that developing hypoxia could not be detected under the laboratory conditions described in this report. Some reflection must be given on those conditions. The most outstanding limit of the study was the constraint of not using, in the university setting, invasive techniques to determine

true arterial oxygenation. It is not known what level of hypoxia each subject experienced. Consequently, one must consider that the individual levels may have been nearly the same, as indicated by the closeness of fit of all the data, and that the FFT and averaging techniques were not able to detect very low level hypoxia. The data do allow for the attainment of the four goals of the investigation: (1) a study of the applicability of sophisticated data reduction techniques in the investigation of sensory processing in humans was accomplished, that is, the FFT and the averaging techniques were simultaneously used to reduce identical data and they both yielded the same results, (2) the ALPHAF and averaging techniques cannot have an impact on the USAF/SAM analogue computer models of human performance because they could not detect marginal brain hypoxia and because the Air Force dismantled the models following the scrapping of the B-1 bomber, (3) the commercial availability of miniature microprocessors now utilizing both the FFT and averaging techniques would allow for onboard human sensory processing capability, and (4) it appears that the FFT and averaged data are not useful for marginally insulted brain function and therefore probably do not have a role in assessment of marginal radiation insult to the brain.

VI. RECOMMENDATIONS

The results of this investigation were not anticipated and the investigator feels that they reflect not an inadequacy of the data reduction techniques, but rather the inability to control the exact level of arterial oxygenation. As USAF/SAM has now completed their sensory evoked monitoring system it would be feasible for Air Force Personnel to repeat this investigation with little expenditure of time or money. By use of arterial gas values, a test subject could be taken just short of hypoxia and his sensory evoked responses studied. Such an investigation by the Air Force would have tremendous impact on future computer models of human performance during times of low level hypoxia.

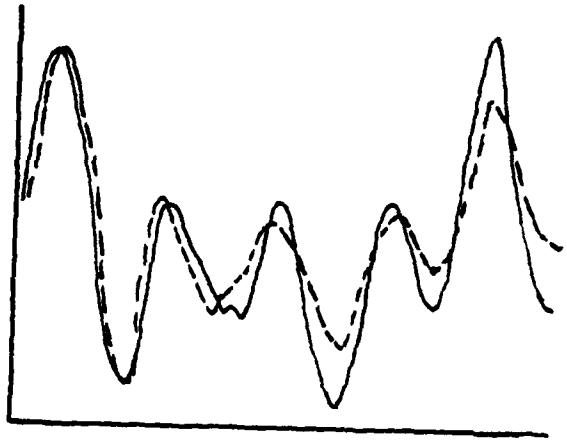


Figure 1. Averaged visual evoked response curves for the normoxic (solid line) and the hypoxic (dashed line; 30,000 feet). Base line is 0.41 seconds. Both the fundamental (3 cps) and the harmonic (6 cps) frequencies were found in both conditions. The slight differences between the normoxic and hypoxic conditions were not greater than those differences found within groups and are therefore not considered to be significant.

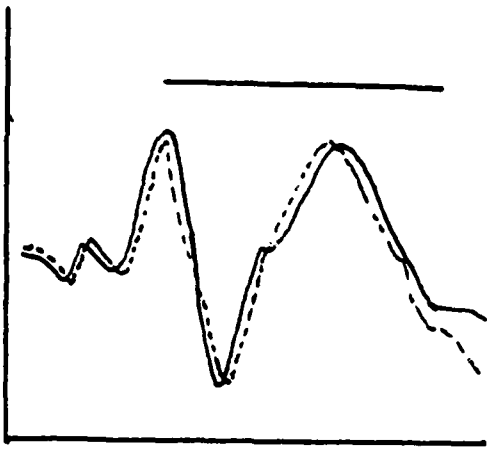


Figure 2. Averaged somatosensory evoked response curves for the normoxic (solid line) and the hypoxic (dashed line; 30,000 feet) conditions. Base line is 0.82 seconds. The portions of the curves below the horizontal line represent cerebral cortex processing. The slight differences are not considered to be significant.

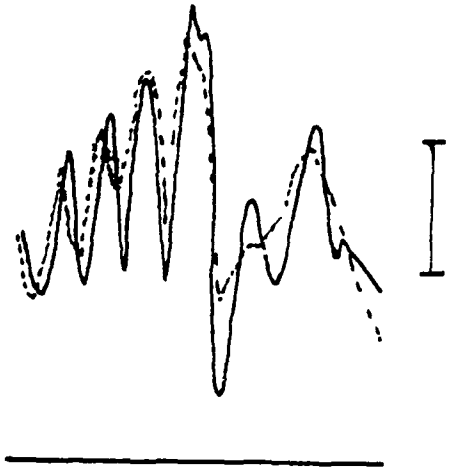
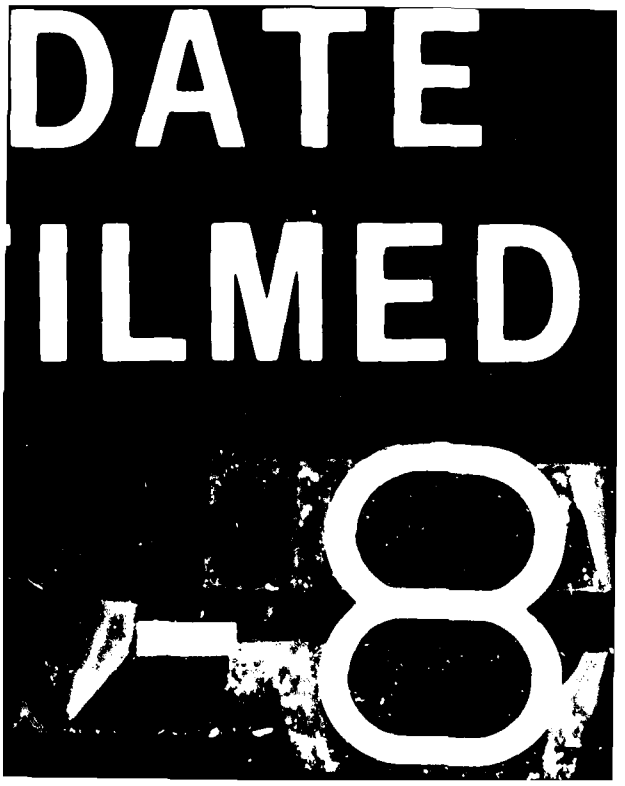


Figure 3. Averaged auditory evoked responses for the normoxic (solid line) and the hypoxic (dashed line; 30,000 feet) conditions. Base line is 0.10 seconds. The slight differences are not beyond normal variation within groups and therefore are not considered to be significant.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